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PRACTICAL CHECKS UPON WATER-WORKS DEPRECIATION ESTIMATES

By Leonard Metcalf

The legal principles governing the determination and accounting of accrued depreciation have been fully discussed heretofore. The most complete analysis of them is to be found in the report of the "Special Committee to Formulate Principles and Methods for the Valuation of Railroad Property and Other Public Utilities," published in the *Proceedings of the American Society of Civil Engineers* in October, 1916.[1]

The discussion herein is limited to the presentation of some important records of actual depreciation developed in the practical administration of water works in different parts of the United States and to showing the necessity for keeping better records of plant abandonments as evidence of actual in contra-distinction to theoretical depreciation. Such records constitute a valuable aid to courts and commissions in fixing just allowances for depreciation in judicial determination, and to water works owners or departments in determining sound financial procedure and safe limits for depreciation accounting.

A striking example of the diversity of opinion sometimes encountered (resulting from an arbitrary following of mathematical and accounting methods), and of the steadying influence of actual records of depreciation in the shape of abandoned property, is to be found in the evidence submitted before the District Court of the United States of the Northern District of California, Second Division, in Spring Valley Water Company vs. City and County of San Francisco et al., Nos. 14275, 14735, 14892, 15131, 15344, 15569, 26, 96, heard in 1915–1916 by the Standing Master-in-Chancery, H. M. Wright, one of the ablest and most experienced judges in rate problems, who had had the advantage of hearing just before this case that of the Contra Costa Water Company vs. City of Oakland et al.

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[1] *Transactions*, vol. lxxxi, December, 1917, p. 1311.

After discussing the theoretical principles governing the accounting and determination of depreciation Judge Wright says, in comment upon the practical aspect of the problem:

> There is no fixed formula for determining what present condition, and consequent present value of a structure, is. Different structures will be differently treated in this respect. The solution of the problem requires the highest exercise of sound judgment. Careful inspection must be made of each structure. The experience of other plants must be borne in mind. The experience of the particular plant must be studied to gain an idea of the rate of depreciation in the past; consideration must be given to influences that may change that rate for the future and so determine the interval that will intervene before replacement is necessary. . . . .
>
> The city's witnesses A and B, find depreciated worth and proper annual allowance by the straight line method. A finds on an estimated reproduction cost of $19,092,000 for all structures, an accrued depreciation in worth of $5,039,000, or 26.4 per cent. . . . . The percentage of depreciation seems excessive when compared with the experience of other plants of similar age. It also strikes me forcibly that so heavy a depreciation as 26.4 per cent is inconsistent with the witness's high commendation of the structural excellence and splendid present condition of the plant. In commending the plant in this way, (and very properly, for all the witnesses are in agreement) the witness had in mind a justification of his estimates of future life, which are longer than those of X and Y (the company's witnesses) rather than of his estimates of present condition and value. It is to be remarked that if he had not adopted long lives, his accrued depreciation would have been still heavier, too great perhaps for the witness himself to justify.
>
> B (the city's other witness) also uses straight line methods. With estimated reproduction cost new of $18,461,000, he gets thus an estimated accrued depreciation of $5,150,000, or 27.9 per cent. He frankly acknowledges that his depreciation in value is attained by the mechanics of his accounting method, by elapsed life rather than by inspection of present condition. He adopts the straight line method because it is simpler in computation; he says "the general principle, 'whatever simplifies serves and whatever complicates is bad,' warrants its adoption." For accounting purposes this may be true, but it obviously results most unjustly in determining the present value of a waterworks midway of its life, whether for rate fixing or condemnation. . . . . The straight line theory takes no account of interest.
>
> X (one of the Company's witnesses) determined the depreciated condition of the various units at the same time as he did the reproduction cost, accumulating the data for both by an actual inspection in the field performed with great thoroughness. He made careful study of the past history of the plant in the matter of depreciation and abandonments. . . . . Where our experience with this or other works enables us to form reliable judgments as to the total life-expectancy of particular classes, of structures, such as flumes, pumps or boilers, he uses a 5 per cent sinking fund curve as a measure of present condition, applied to the life in question. In particular cases, as of

> hard service, or poor design of pumps, he sometimes estimates percentage condition at once by an effort of judgment. . . . . This brief survey will illustrate the practical nature of X's methods of determining present percentage condition.
>
> Y's estimate (the other Company's witness) of accrued depreciation follows much more closely the sinking fund method on a 4 per cent curve of depreciation. He likewise made close investigation, by inspection in the field, of present condition of structures. While X's mental attitude is to estimate percentage condition first, and deduce remaining lives from that, Y finds it easier and deems it safe to work from a life estimate primarily, adopted from his experience, and check the resulting percentage condition, as to its reasonableness, by inspection and consideration of all surrounding conditions.

The Company's estimates of accrued depreciation amounted respectively to $3,192,455 or *12.7 per cent* on a gross reproduction cost of $25,125,843; and $3,496,847 or *13.9 per cent* on $25,128,930. After certain eliminations the Master refers to these percentages as *12.1 per cent* and *13.7 per cent.* On careful analysis of the evidence submitted the Master concludes:

> At best the determination is an estimate. . . . . A figure of *13 per cent* seems to me fair. This gives a deduction from gross reproduction cost new, $21,537,000, of $2,800,000. Expressed as a percentage of structures subject to depreciation, rather than of all the structures, (for the Master eliminated some structures, such as the large storage reservoirs and certain of the tunnels as not subject to depreciation), this sum of $2,800,000 would be a larger percentage, perhaps 16 per cent, but I have not thought it important to make the computation.

While the Master's conclusion was undoubtedly the result of that judicial discrimination and weighing of the evidence which the law contemplates, it seems highly probable, and his comments indicate, that the actual historical record of abandonments in this particular plant during its life history of fifty-five years, and similar evidence of the life history of structural water works properties elsewhere, was of material assistance to him in making his decision. The historical evidence relating to the fair annual depreciation allowance may not have been equally helpful to him, because of the considerable range in results adduced in the small number of plants—five—the life history of which was cited.

It cannot be doubted, however, that a wider range of historic record, which can be had at the slight expense of the keeping by public service corporations of more systematic records of abandonments, will be found helpful and serve to prevent the carrying of theoretical deductions and methods of accounting to unwarranted limits.

It was with this end in view that Allen Hazen and the author have been trying for the past fifteen years or more to gather well-authenticated complete historic records of abandonments of structures by water-works properties in this country. The record of eleven works may seem meager for so long a period of years, but this merely indicates the imperfect character of corporation records of plant abandonments and the difficulty of assembling reliable information relating to them. The results which follow may serve, however, as a nucleus, and may stimulate further contribution from others who may have been doing the same thing and the future search for similar available information.

In comment upon these records the following notes are of significance.

Of the eleven records submitted, five were published, in skeleton only, as Appendix IV of the Committee's report[2] heretofore alluded to, with the following significant introduction,—

RECORDS OF ABANDONED PROPERTY

> The Committee calls the attention of engineers and administrators of public utility properties to the desirability of keeping as clear and complete a record as possible of the property abandoned by the corporation, annually and in aggregate amount.
>
> Such records will be of great service to courts and commissions, in assisting them to determine the annual depreciation allowance which should fairly be made for any public utility property, in the light of its past history, as well as of an intelligent forecast of its probable future.
>
> It is obvious that such record—when used as a check upon, or when coupled with, an estimate of the accrued depreciation on the existing property,—will reduce substantially the element of uncertainty, which must attend all such computations, based, as they must always be, upon probable future, as well as on past conditions.
>
> As an example of such records within the waterworks field, and of their applicability, the following table is cited, embodying the results of a continuous effort to collect such data, during a period of fifteen years more or less, on the part of Allen Hazen and Leonard Metcalf, Members Am. Soc. C. E.
>
> It seems highly probable that by keeping such records in detail, there will be developed, in the course of time, sufficient information to admit of the setting aside of the fair annual depreciation allowance on a basis of percentage-of-gross-revenue of the operating company, a method which would have much advantage, on account of its simplicity of accounting, as well as for other reasons.

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[2] *Transactions American Society Civil Engineers*, vol. lxxxi, December, 1917, p. 1582.

Inasmuch as this table is submitted for suggestive purposes only, and not for direct application, it is unnecessary to record here a description of the various plants, or the methods of determining the figures contained in the record, though it may be added that these figures have been taken in large measure from authoritative sources, such as court, commission or agreed, findings.

The figures then submitted have since been slightly revised to accord with the Master's and court's decision in the Spring Valley Water Company case, somewhat expanded and materially added to. To make the record of service to others, brief notes follow, characterizing the plants, the depreciation records of which are submitted.

Portland, Maine, (1907. Hazen and Metcalf.) The statistics relate to the works of the Portland Water Company and three subsidiary companies taken together and treated as one plant. The estimated cost of reproduction was agreed upon by four engineers, two representing each side, in a proceeding that resulted in a transfer of the property. These engineers did not agree upon the depreciation but each made his own estimate. The depreciation estimates differed considerably on the two sides,—though all four engineers used the sinking fund basis of determination, checked by careful inspection of structures themselves,—and the average of the four is taken. The plant was peculiar in that some of the main parts had ceased to be adequate, and while they were in fair physical condition and capable of service for many years, the needs of the district were such that new works were required to replace them. Under these conditions a functional depreciation was claimed by the engineers representing the Water District in excess of physical depreciation and it is largely to this fact that the relatively high annual depreciation found by the computations must be attributed.

It may also be noted that some expensive parts of the works had been built with inadequate engineering advice and were not very well adapted to the service required of them, and this also was a matter taken into account in estimating the depreciation on existing structures.

Racine, Wis., Water Company (1913, Hazen). The values and the estimated depreciation are those made by Allen Hazen in valuing the plant in 1913. The cost of the discarded structures was estimated by the local manager from quite full records. The Racine plant was very well built, future growth was liberally anticipated and the growth of the city has not been so rapid as to make it necessary to discard any important part of the plant. The Lake Michigan water dispensed by it is remarkable for the small effect which it has upon the pipes through which it flows, and this tended to reduce depreciation. Taking these matters into account, the depreciation at Racine must be considered as unusually low and much below the average. The plant is also a comparatively young one and this may have some effect.

Denver Union Water Company, Denver, Colo. (1913, Metcalf). The record of the Denver Union Water Company data was prepared at the time of the trial of the rating suit (May, 1914,) the basic valuation being made as of October 31, 1913.

The Denver plant comprises some structures relatively less durable than those of the Spring Valley Water Company or of the Portland Water District, which has increased the rate of depreciation. These structures are the main conduit lines, upwards of 100 miles in length, built of wood stave pipe, whereas the Spring Valley Water Company conduits were built of wrought iron. The pumping plants are also of somewhat less substantial type. The dams and distribution pipe systems, on the other hand, are of equally enduring type.

A considerable depreciation in abandoned property resulted at Denver from bitter competition just prior to the consolidation of the two predecessor companies which were united in the Denver Union Water Company about the year 1894, and which themselves represented a consolidation of several smaller companies.

The engineers to the Public Utilities Commission of Denver rejected the straight line method of determining depreciation, as giving extreme results repugnant to their judgment, and, as the engineers to the Company, adopted the sinking fund basis (with 4 per cent rate), checked by careful examination of the structures themselves. The Master's depreciation figures were in close accord with the author's and but slightly different from those of the City's representatives.

The Denver depreciation has been figured on the basis of the author's detailed analysis and the Master's findings. The latter excluded from the rating base the Sullivan Reservoir, the paving-over-mains, and some of the street obstructions.

Pennsylvania Water Company, Wilkinsburg, Pa. (1911, Metcalf). This record was obtained by the author April, 1911, assisted by the Engineer and General Manager of the Company, William C. Hawley, M.Am.Soc.C.E.

These works supply certain wards of the City of Pittsburg, the City of Wilkinsburg and a number of other cities or towns stretching for a distance of fifteen miles, more or less, to the east of Pittsburg and then comprising a population of about 90,000.

The plant is located in the heart of the steel manufacturing district and operates under very trying circumstances, supplying water at varying elevations up to 600 feet above the source of supply. The first supply was derived from the Monongahela River which had to be abandoned, except as an emergency supply, on account of the change in character of this water due to mining operations on the river which made the water too acid for domestic use. The new supply, comes from the Allegheny River and has to be lifted approximately 600 feet on to the top of a hill where it is filtered and distributed to the various levels of the city.

The records of the Pennsylvania Water Company indicate that the average annual rate of depreciation for the period of years from the construction of the plant in 1888–1889 to the date of valuation, 1911, was 1.3 per cent of the gross reproduction cost of the structures, which probably, but lightly exceeded their original cost; and that the annual depreciation amounts to approximately 8 per cent of the gross annual revenue during this period of years. In comment upon the latter figure, it is to be noted that the gross annual revenue was found to be inadequate in the rating case (1911) and that the revenue after the enforcement of the new rate schedule was substantially increased. Had the actual revenues been on the higher adjudicated scale, it would have had the effect of decreasing the depreciation (8 per cent) shown above as measured in terms of the gross annual revenue. The data are, however, not sufficiently exact to justify any such reduction, but it is probably fair to assume that the stated allowance of 8 per cent of gross annual revenue is a fairly reasonable one.

Spring Valley Water Company, San Francisco, Cal. (1913, Metcalf). The structures of the Spring Valley Water Company are of an unusually well built and enduring kind. The earthen and masonry storage reservoirs are very substantially built, and are likely to be used for a very long period of years, if not for all time. The conduit lines were built of wrought iron and coated by Hermann Schussler, M. Am. Soc. C. E., with a special coating and after varying periods of service up to 45 years show remarkable freedom from corrosion or tuberculation. The pumping plants are of very substantial character. The distributing reservoirs are well built, and the distributing system is good and sound, though it will require reinforcement in certain sections with increase in density in population.

The abandoned-structures and structures-never-in-use in the system of the Spring Valley Water Company amount to $3,420,000, being nearly equal in amount to the accrued depreciation upon the existing structures.

The figures are based upon the findings of Hon. H. M. Wright, Standing Master in Chancery of the U. S. Federal Court of the Northern District of California, rendered in 1917, as of date December 31, 1913.

Indianapolis Water Company, Indiana, (1915, Metcalf). This record was obtained by the author from the records and officers and employees of the Company, in November, 1916.

The works of the Indianapolis Water Company are of very substantial type. The pipe system is substantially wholly of cast iron and of unsually ample dimensions. The pumping stations have been well built and equipped with heavy machinery of very good efficiency, the old Snow pump for many years holding the record for the highest duty developed by any triple-expansion flywheel engine in this country and still operating very economically. A very important element of the property is the canal approximately 9 miles long, delivering the water supply by gravity to the coagulating basins and filters, and the balance of the water to the Washington Street Station in the heart of the city, where power is developed from it to pump the filtered water to the consumer. The canal is without probability of abandonment or material depreciation, and constitutes perhaps one-sixth, more or less, of the entire property. The filter plant and appurtenant structures are of good type, though some extension of the plant and modification in method of operation may be necessary in the future when the city grows to materially larger dimensions.

The property may be characterized as one of the best-built and maintained water works in the United States.

East Chicago and Indiana Harbor Water Company, Indiana (1917, Metcalf). Record worked up in connection with the hearings upon the petition of the city, for filtered water, before the Public Utility Commission of Indiana, though much of the data was assembled during the period from 1904 to 1912 during which the author represented the bondholders and the owners of the property in the supervision of the management of the works.

This is a record of abnomally high depreciation developed in a city which has grown unusually rapidly, increasing from a population of 1255 in 1890, and 3411 in 1900, to 19,098 in 1910, and 33,000 in 1917.

The original works were cheaply built and the original machinery had soon to be superseded. The greater part of the depreciation is due to the abandonment of one of the lake intake pipe lines, 3,000 feet in length, of 16-inch spiral riveted flanged steel pipe. It accounts for $40,000 out of a total property abandonment of $94,000.

The present plant is a substantially built one, of the pumping type.

A Central New York Plant (1916, Metcalf). The record of the depreciation data was worked up from the records of the Company, with the assistance of the older employees, as of December 31, 1916.

The structural plant has been built largely within the past 20 years. The plant has been well built and is of long-lived character. It consists of large storage reservoirs located on opposite sides of the city, built in most cases of earth with paved slopes, cast iron supply mains 20-inch and upward in diameter, bringing the water to the city; and cast iron distribution pipe system of fair size with feeders of good capacity. The booster pumping plants are of minor character and small cost.

The amount of depreciation fully developed in the form of abandoned property is comparatively small, the chief items being an earthen dam which burst during a flood, and the distribution pipe system replaced with mains of larger diameter.

Concord, Mass., Water Works—Municipal (1917, Leonard Metcalf, Chairman of Water and Sewer Commissioners). The Concord water works were built originally in 1874, by William Wheeler, M. Am. Soc. C. E., and consisted of a gravity supply fom Sandy Pond, delivered through wrought iron cement-lined mains 10 inches and smaller in diameter, to Nashawtuc Reservoir. They were substantially reinforced by the addition of a second main of wrought iron cement-lined pipe, from Sandy Pond to the center of the town, in 1883. Some additional wrought iron cement-lined pipe was laid in the interval between these two dates and subsequently as late as 1890, the total amount aggregating an approximate cost of $142,000.

In 1909 additional gravity supply was obtained from Nagog Pond, on the opposite side of the town from the old supply and delivered through a compound 16-inch and 12-inch cast iron pipe line into a high service fire protection system, by small motor-driven centrifugal pump, boosting the water from the low service into the high service mains, storing water in a new reservoir (Annursnack) of 2,500,000 gallons capacity. The works were well-built and the original use of wrought iron cement-lined pipe in preference to the then more costly cast iron pipe was well justified, as the life history of the plant has demonstrated. Owing in part to the construction of the sewer system, which resulted in lowering the ground water table, and in some settlement of the water pipe system, as well as to the effect upon the low-service system pipe of the subsequently introduced high-service supply (put upon the mains during times of fire), wrought iron cement-lined pipe of an aggregate cost of approximately $20,800 had to be replaced with cast iron pipe, and it is probable that the life of the remainder of the wrought iron cement-lined pipe will be substantially shorter than would have been the case with cast iron pipe.

The record of accrued depreciation within the life history of the plant, from 1874 to 1917, both inclusive, has therefore been figured upon two bases,

Actual depreciation of Concord, Mass., water works, and depreciation figured on plant using cast iron pipe

ITEMS	ON BASIS OF EXISTING PLANT	ON MODIFIED BASIS OF CAST IRON PIPE INSTEAD OF WROUGHT IRON CEMENT-LINED PIPE
Date of record	Dec. 31, 1917	Dec. 31, 1917
Authority	Metcalf	Metcalf
Population	6,733	6,733
Whole period of operation in years	44	44
Average age of investment in years	18.3	18.3
Gross revenue during whole operating period	$703,000	$703,000
Gross cost of existing structures	$380,200	$380,200
Cost of abandoned structures	$41,200	$ 31,200
Combined cost of existing and abandoned structures	$421,400	$411,400
Accrued depreciation on existing structures	$68,700	$42,200
Accrued depreciation on existing structures expressed as percentage	18.1%	11.1%
Accrued depreciation in abandoned structures	41,200	31,200
Accrued depreciation in abandoned structures expressed as percentage	9.8%	7.6%
Total depreciation in amount	$109,900	$73,400
Total depreciation in percentage on cost of existing and abandoned plant	26.1%	17.8%
Total depreciation in percentage on cost of existing plant	30%	19.8%
Average annual depreciation in percentage based upon		
(a) cost of existing plus abandoned structures	1.42%	0.98%
(b) Net or depreciated cost of existing structures only	1.64%	1.08%
(c) gross revenue, during whole operating period	15.6%	10.4%
(d) per capita (total depreciation divided by present population times average age)	89¢	59.7¢

the first, the system as it stands, the second upon a modification of the accrued depreciation to determine the difference which would probably have resulted had cast iron pipe been used instead of wrought iron cement-lined pipe, for the purpose of comparing this record with other similar data.

In making the analysis on a cast iron pipe basis, it has been assumed that the abandoned wrought iron cement-lined pipe, aggregating $20,800 approximately, would probably have been reduced by the sum of at least $10,000; and that the average life of the cast iron pipe system assumed to replace the existing wrought iron pipe system, would have been 75 years, instead of 50 years assumed for the latter, much of which is already 43 years old. Under these circumstances the accrued depreciation upon the existing pipe system (with cast iron substituted for wrought iron cement-lined pipe) would be $13,500, instead of $40,000, and the total accrued depreciation upon existing plant would be reduced from $68,700 to $42,200. The comparative results are shown on preceding page.

A southern seaboard state plant (1917, Metcalf). The record of total depreciation upon this plant was worked up by the author with the assistance of the officers of the Company, in connection with the valuation of the property as of December 31, 1917.

The works were originally built in 1888, but owing to the abnormally rapid growth of the city, beginning about 1906, the average age of the investment is but 10 years.

The plant consists of a driven well system, the older wells being 10 inches in diameter for the most part, and varying in depth from 165 to 320 feet, running into the Vicksburg limestone, the water supply being pumped by reciprocating pumps, substantially a direct pressure system, operating under 65 pounds per square inch pressure, more or less, increased to 100 pounds at times of fire.

The wells recently built (Substations 1 and 2) are 12 and 15 inches in diameter, approximately 240 to 300 feet deep. They are equipped with motor-driven, two-stage, centrifugal pumps.

The pipe system is of cast iron of good dimensions. The 3,500,000 gallon reinforced concrete storage reservoir built in 1915, is a well built structure of this type. The works are of good character.

Portsmouth, Berkley and Suffolk Water Company, Va. (1918, Metcalf). This record was obtained by the author sitting as one of a board of three arbitrators appointed to fix the fair value of the property of the company as of April 1, 1918.

The present company was incorporated in 1902 and comprised predecessor companies built in the late eighties. Its water supply, which is ample for the growing population, is derived from the Suffolk lakes, probably the most available and desirable water supply in this general region, developed by substantial storage dams. The water, which is of good quality though somewhat hard and high in color as are the waters of this region, is lifted to and passes through coagulating basins, aerators and mechanical filters, and is then pumped, by compound condensing double-acting duplex pumps, at a pressure of 100 pounds per square inch, into and transported through cast iron conduits a distance of about 18 miles to Portsmouth. Substantially all of this pressure head is consumed in overcoming the frictional resistance in this distance, and at Portsmouth the water is repumped into a standpipe and to the consumers by pumps of similar type. A 14-inch flexible-joint, cast iron pipe line carries the water under the harbor (the Elizabeth River) to the Berkley standpipe and consumers.

The distribution pipe system is largely of cast iron pipe, though there is a considerable percentage of small wrought iron pipe supplying sections of the city without fire hydrant service. The plant is fairly characteristic of early water works practice in this country, conscientiously built and well maintained under difficult natural and financial conditions.

The depreciation estimate was made on the sinking fund basis, on age and expectancy of life figures submitted by the engineers to the parties at issue, and was subsequently analyzed and modified by one of the members of the Board, as a basis for its discussion. It served as an aid to judgment, though it was not acted upon by the Board, except in so far as weight may have attached to it in its bearing upon net reproduction cost or other measure of value considered in the final determination of the fair value of the property.

COMMENTS UPON ELEVEN RECORDS CITED IN TABLE 1

The record covers eleven water-works properties serving cities from 6700 to 500,000 population.

The range of age or elapsed life varies from twenty-two to sixty-seven years; the corresponding average age of investment, from eleven to twenty-six years, the difference between the two being due to the fact that the construction work during the more recent years has been greater than in the earlier years of the life history of the plants under consideration.

The gross revenue earned during the whole operating life of each of the plants was obtained from its records. In some cases, owing to lack of available data, the revenue during the first few years of the plant's life had to be estimated from the best evidence available, but the effect of any probable error in the correctness of this estimate is likely to be insignificant in the resulting averages and certainly within the limits of accuracy or direct applicability of such records.

The original cost of the structures includes the actual, or a moderate allowance for the estimated, overhead and interest-during-construction charges, on the assumption that the overhead costs were partly carried by operating expenses. Where reproduction costs had to be used, fair allowance has been made, and in all cases similar bases of cost have been used for the analyses of annual and accrued depreciation. The cost shown does not represent the cost or the fair value of the entire property in any instance cited, because it excludes real estate, going value, water rights, intangible values and perhaps some other items or elements of value. It covers structure costs only. The Denver and San Francisco figures are based upon Federal Court decision; the Indianapolis, upon Public Service Commission finding; the Portland, upon an average of the contentions of the plaintiff and defendant, which differed by about 3 per cent, if the author's memory serves him rightly; the East Chicago, upon a valuation by John W. Alvord, M. Am. Soc. C. E., roughly checked by the author and varying but little from the contentions of the city's representative, Samuel A. Greeley, M. Am. Soc. C. E., and the six remaining cases were based upon the analyses of Allen Hazen, Emil Kuichling and the author, respectively.

The abandoned structures were determined from the corporate records in every case, with the assistance of the employees having the best information concerning the structures, the original cost being used where available, otherwise the reproduction cost.

The accrued depreciation upon the existing structures was estimated after examining the property and the records of the Company, careful study of the records of abandoned structures, using the sinking fund method (see later discussion on reason for using this method) of computation, based upon elapsed life, with 4 per cent interest rate, merely as an aid to judgment; giving consideration also to other practical factors such, for instance, as those revealed by inspection, by the operating records, by repair accounts and by the loss in carrying capacity of the pipe distribution system. Where available, the finding of the court as to the accrued depreciation upon existing structures was utilized; otherwise an average of the witnesses for the plaintiff and defendants or the estimate of the individual as stated.

Where these estimates of accrued depreciation upon existing property are in error, the total depreciation estimate also will be in error, but in much smaller measure, as the amount of the abandoned structures, which is known, is also involved. It may be noted, too, that the estimates upon all but the Racine case were made by the same person whose depreciation estimates were in close consonance with the finding of the Federal Court in the Denver and San Francisco cases.

The accrued depreciation upon existing structures, shown in total and average annual percentage, is based upon the existing structures only; that of the abandoned structures upon the combined amount of existing and abandoned structures.

	PORTLAND, ME., WATER DIST. (AVERAGE OF PLAINTIFF AND DEFENDANT)	RACINE, WIS. (HAZEN)
1. Date of record	1907	1913
2. Authority	Hazen and Metcalf	Hazen
3. Population	78,200	38,000
4. Whole period of operation, years	39	26
5. Average age of investment, years	18	16
6. Gross revenue during whole operating period	\$6,605,000	\$1,343,000
7. Gross reproduction cost of structures	2,594,000	1,219,000
8. Abandoned structures (actual or reproduction) cost.	137,000	19,000
9. Total (including overhead and interest during construction)	\$2,731,000	\$1,238,000
10. *Accrued depreciation* on existing structures (reproduction cost)	\$498,000 = 19.2%	\$70,600 = 5.8%
11. Accrued depreciation—in abandoned structures, actual (or reproduction) cost	137,000 = 5.0%	19,100 = 1.54%
12. Total amount in existing and abandoned structures.	\$635,000	\$89,700
13. Total depreciation in per cent on gross reproduction cost (on existing and abandoned structures)	23.2%	7.2%
14. Total depreciation in per cent on average net reproduction cost of existing structures (see 21 below)	26.3%	7.5%
Average annual depreciation in per cent based upon		
15. (a) Gross reproduction cost and abandoned structures	$\frac{23.2}{18} = 1.29\%$	$\frac{7.2}{16} = 0.45\%$
16. (b) Net reproduction cost of existing structures only, or gross reproduction plus abandonments, less one-half total depreciation, divided by average age	$\frac{26.2}{18} = 1.46\%$	$\frac{7.5}{16} = 0.47\%$
17. (c) Gross revenue during whole operating period	9.6%	6.7%
18. (d) Per capita (total depreciation divided by present population times average age)	\$0.45	\$0.15
19. Gross reproduction existing and abandoned property.	\$2,731,000	\$1,238,000
20. Minus one-half combined depreciation	317,500	44,850
21. Average net reproduction cost	\$2,413,500	\$1,193,150

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* See notes upon this property showing effect upon depreciation record of the wrought iron

† Figures 7.52 per cent. 8 per cent believed to be a fairer figure, however.

‡ Including Sullivan reservoir.

§ On basis of original cost of structures of \$21,306,000, a straight-line depreciation rate of 1.25

|| Heavy depreciation due to use of iron cement-lined pipe.

¶ Based upon decision Indiana Public Service Commission, March 15, 1917.

** 14.2 years (approximate) on sinking fund basis applied to existing structures.

†† Based upon decision of Judge H. M. Wright, Standing Master in Chancery. United States

‡‡ Average plaintiff and defendant engineers.

§§ Prewar prices.

TABLE 1

Depreciation records of some ol

RACINE, WIS. (HAZEN)	DENVER UNION WATER COMPANY, COLO. (FEDERAL COURT)	PENNSYLVANIA WATER COMPANY WILKINSBURG, PA. (METCALF)	SPRING VALLEY WATER COMPANY SAN FRANCISCO, CAL. (FEDERAL COURT)††	INDIANAPOLI COMPA INDIANAPOLIS, (PUBLIC SE COMMISSI
1913	1913	1911	1913	December
Hazen	Metcalf	Metcalf	Hazen and Metcalf	Metca
38,000	242,000	90,000	453,000	270,0
26	43	23	55	45
16	20	12	26	16*
$1,343,000	$22,000,000	$3,923,000	$76,968,000	$13,972
1,219,000	10,411,438	3,128,389	21,537,000	7,906
19,000	1,420,505	250,000	3,420,000	883
$1,238,000	$11,831,943	$3,378,389	$24,957,000	$8,789
$70,600 = 5.8%	$1,320,970 = 12.7%	$271,700 = 8.7%	$2,800,000 = 13%	$736,000 =
19,100 = 1.54%	1,420,505‡ = 12.0%	250,000 = 7.4%	3,420,000 = 13.7%	883,000 =
$89,700	$2,741,475	$521,700	$6,220,000	$1,619,000
7.2%	23.2%	15.4%	24.9%	18.4
7.5%	26.2%	16.7%	28.5%	20.3
$\frac{7.2}{16} = 0.45\%$	$\frac{23.2}{20} = 1.16\%$	$\frac{15.4}{12} = 1.29\%$	$\frac{24.9}{26} = 0.96\%$§	1.13
$\frac{7.5}{16} = 0.47\%$	$\frac{26.2}{20} = 1.31\%$	$\frac{16.7}{12} = 1.39\%$	$\frac{28.5}{26} = 1.10\%$	1.23
6.7%	12.4%	8.00%†	8.1%	11.6
$0.15	$0.57	$0.48	$0.53	$0.4
$1,238,000	$11,831,943	$3,378,389	$24,957,000	$8,789
44,850	1,370,737	260,850	3,110,000	809
$1,193,150	$10,461,206	$3,117,539	$21,847,000	$7,979

the wrought iron cement lined pipes and probable results had cast iron pipe been used to wit:—
r.

ciation rate of 1.25 per cent was found to yield $6,774,000, depreciation allowance (including aban

17.
uctures.
ry. United States District Court, Northern District of California, 1917.

TABLE 1

n records of some old water works

VATER CAL. RT)††	INDIANAPOLIS WATER COMPANY INDIANAPOLIS, INDIANA (PUBLIC SERVICE COMMISSION) ¶	E. CHICAGO AND INDIANA HARBOR WATER COMPANY E. CHICAGO, IND.‡‡	A CENTRAL NEW YORK PLANT (METCALF)	CONCORD, MASS.* (METCALF)	A SOUT
	December, 1915	November, 1915	December 31, 1916		Dece
etcalf	Metcalf	Metcalf	Metcalf	Metcalf	
	270,000	29,600	102,000	6,750	
	45	22	67	43	
	16**	11	22	18.3	
0	$13,972,000	$805,000 (est.)	$6,841,000	$703,000	
0	7,906,000	609,400	4,509,000	380,200	
0	883,000	94,400	285,000	41,200	
0	$8,789,000	$703,800	$4,794,000	$421,400	
3%	$736,000 = 9.3%	$63,500 = 10.4%	$353,000 = 7.8%	$68,700 = 18.1%	$118,
3.7%	883,000 = 10.0%	94,400 = 13.4%	285,000 = 6.3%	41,200 = 9.8%	40,
	$1,619,000	$157,900	$638,000	$109,900	$158,
	18.4%	22.4%	13.3%	26.1%	
	20.3%	25.3%	14.1%	30.0%	
%§	1.13%	$\frac{22.4}{11} = 2.04\%$	0.62%	$\frac{26.1}{18.3} = 1.42\%$||	$\frac{16.6}{13\text{ y}}$
%	1.23%	$\frac{25.3}{11} = 2.3\%$	0.66%	$\frac{30}{18.3} = 1.64\%$	$\frac{18.05}{13}$
	11.6%	19.6%	9.3%	15.6%	
	$0.42	$0.48	$0.29	$0.89	
0	$8,789,000	$703,800	$4,794,000	$421,400	
0	809,500	78,950	319,000	54,950	
0	$7,979,500	$624,850	$4,475,000	366,450	

een used to wit:—annual depreciation (a) = 0.98 per cent; (b) = 1.08 per cent; (c) =10.4 per ce

ce (including abandoned property) as of Dec. 31, 1913. Note that $\frac{\$21{,}306{,}000}{24{,}957{,}000}$ × 1.25 per cent = 1.

D, MASS.* TCALF)	A SOUTHERN SEABOARD PLANT (METCALF)	PORTSMOUTH, BERKLEY AND SUFFOLK WATER COMPANY, VA.	RANGE	ESTIMATED NORMAL AVERAGE (APPROXIMATE)
	December 31, 1917	April 1, 1918		
tcalf	Metcalf	Metcalf		
,750	68,800	80,000	6,750–453,000	
43	28	30	22–67	
8.3	13	13.1	11–26	
3,000	$2,502,000	$3,983,000		
0,200	913,118§§	2,009,000§§		
1,200	40,000	165,000		
1,400	$953,118	2,174,000		
0 = 18.1%	$118,000 = 12.93%	$186,000 = 9.2%	5.8%–19.2%	8%–13% **Aver. 11.6%**
0 = 9.8% 0	40,000 = 4.38% $158,000	$165,000 $351,000 = 16.1%	1.5%–16.1%	6%–12% Aver. 9.1%
.1%	16.6%	16.1%	7.2%–26.1%	Aver. 18.8%
.0%	18.05%	17.6%	7.5%–30.0%	Aver. 21.0%
= 1.42%‖	$\frac{16.6}{13 \text{ yrs.}} = 1.28\%$	1.23%	0.45%–2.04%	0.9%–1.3% **Aver. 1.17%**
= 1.64%	$\frac{18.05}{13 \text{ yrs.}} = 1.39\%$	1.34%	0.47%– 2.3%	1.0%–1.4% **Aver. 1.3%**
.6%	6.31%	8.8%	6.31%–19.6%	8%–12% **Aver. 10.4%**
0.89	$0.22	$0.33	$0.15–$0.89	$0.40–$0.50 **Aver. 43¢**
1,400 4,950 6,450	$953,118 79,000 874,118	$2,174,000 175,500 $1,998,500		

; (c) =10.4 per cent; (d) = 60 cents.

1.25 per cent = 1.07 per cent, an approximate check.

The total depreciation in percentage of the average net or depreciated cost is found by dividing the combined amount of the depreciation upon existing and abandoned structures, by the combined cost of existing and abandoned structures, less one-half of the total depreciation, the latter being made up of the depreciation upon existing and abandoned structures.

The average *annual depreciation, in percentage of the cost or of the gross-reproduction-cost-of-existing-and-abandoned structures,* is found by dividing the total depreciation, expressed in percentage, by the average age of the investment (in structures only).

The average *annual depreciation, in percentage of the net-or-depreciated cost* is found by dividing the total percentage depreciation upon existing structures only, found as previously described, by the average age of investment in structures.

The average *annual depreciation, in percentage of gross-revenue* during the entire operating life of the plant, is found by dividing the total depreciation upon the existing and abandoned structures, by the gross revenue during the life history of the plant, and this quotient by the average age in years of the investment in structures.

The average *annual depreciation per capita* is found by dividing the total depreciation upon existing and abandoned structures, by the present population and this quotient by the average age in years of the investment in structures.

REASONS FOR USING SINKING FUND METHOD FOR DETERMINING ACCRUED DEPRECIATION UPON EXISTING STRUCTURES IN REFERENCE TO OTHER METHODS

First. In the present state of knowledge of depreciation actually developed or realized in different water works, and of fair provision for and accounting of depreciation in *water works property,* the sinking fund method has been found to more closely follow the true depreciation (in contradistinction to the theoretical accounting allowance) than any other, though it too must be applied in the light of the *observed conditions.*

Later when experience shall have crystallized into more specific, reliable and comprehensive record, it may well be possible to use simpler and more direct methods for determining actual accrued depreciation and fair annual depreciation allowance.

Second. As applied to *long-lived* properties such as water-works, it is the method most generally used by engineers and others who have most thoroughly and judicially studied such records.

Third. While with *short-lived,* or *recently built* long-lived properties the difference resulting from the determination of accrued depreciation by the application of different methods, such as the straight line, the sinking fund, the equal-annual-payment, and others, to life expectancies of structures, is comparatively slight, this difference becomes seriously unfair with all long-lived properties.

It is generally found that when the straight line method of determining accrued depreciation is applied to water-works from twenty to forty years or more old, the result is obviously at variance with the actual condition of the structures and the service rendered by them, often so extremely so as to be repugnant to fair judgment. Thus, in the Denver rate case of 1913, the engineers to the Public Utilities Commission figured accrued depreciation by both the sinking fund and by the straight-line-method, and rejected the results obtained by the latter as being obviously excessive and out of line with the condition of the structures carefully observed by them. They finally adopted the sinking fund method, with 4 per cent rate, as a basis of computation for aiding and in many cases determining judgment. The results thus obtained were in fairly close accord with those found by the engineers to the Denver Union Water Company and those adopted by the Master of the Federal Court before whom the case was tried.

Similarly in the Spring Valley Water Company vs. City of San Francisco (1908–1916) alluded to at the beginning of this paper, the Standing Master in Chancery, Judge H. M. Wright, rejected the results obtained by the application of the straight-line-method to the determination of the accrued depreciation as excessive, unjust and unwarranted and adopted an amount in close accord with the result derived by sinking fund methods.

Judge Wright's comments are significant:

> The *modified sinking-fund method* is one of two correct methods by which depreciation may be amortized throughout the life of the structure, when the value thereof is depreciated each year. It is the only method which shows present worth in any year after the first.
>
> On the other hand, a defect of the *straight-line method* of amortization is that it casts the heavier burden of payments upon the ratepayer of the early years when revenues are low, and, expressed in terms of value of service, when the load-factor of the unit is low.

Now, I emphasize again the fact that we have been discussing accounting or book-keeping methods adopted to satisfy by current money payments, the ratepayer's obligation to pay the owner interest on the capital employed and to provide the capital necessary to replace a structure which depreciates in service; in other words, these are mere matters of arithmetic. All will work out justly if followed from the beginning to the end of the life of the structure. On the other hand, the necessary amortization will not be accomplished if any selected method is pursued only for part of the estimated life; or when one method is followed for part of the life and another method for the residue. This is self-evident.

It is also important to emphasize the fact that except in the first and last years, these various figures illustrative of cost-accounting methods bear no necessary relation to annual depreciation in value of the structure *in fact*, or to the depreciated value of the structure, its value for sale purposes, in any given year. Both the modified sinking-fund method and the straight-line method are correct accounting methods, proper to be incorporated in advance, for example, in a contract between the state and a public service corporation. But where there is no contract, and the inquiry is, as in this case, directed to a determination of the *fact of present value in a given year*, both these methods cannot be equally right. In the example in the tables, for instance, the structure would be worth at the end of the sixth year, $47,080 by the modified sinking-fund method, and $40,000 by the straight-line method.

It has been necessary to discuss at length these accounting methods, first as an introduction to a proper understanding of the problem in hand and secondly to show the palpable error of reckoning present worth and proper annual allowance purely on the basis of a cost-accounting method, without reference to actual condition and value in fact.

The problems involved in depreciation have only recently been studied and appreciated. The Spring Valley Water Company did not establish a depreciation reserve until 1908 (Exhibit 174); and this was the case generally throughout the country (7963). The Knoxville decision in January, 1909, marked the time of change in accounting practice. Prior to that, all renewals and replacements were charged to operating account—the replacement method above; the public thus paid only for matured depreciation, and nothing on account of accruing but unmatured depreciation. In this state, the decisions of the Supreme Court refused sanction to an annual allowance for depreciation reserve in San Diego Water Co. v. San Diego, 1897, 118 Cal. 556, 583, and Redlands Water Co. v Redlands, 1898, 121 Cal. 312. It is to be noted that the late Chief Justic Beatty, in a dissenting opinion, page 588, said that "an annual allowance should be made for a sinking fund" sufficient to effect replacement of depreciated plant.

It is evident, therefore, that we have before us in the case of the plaintiff, a situation where accounting practice has changed at a point part way through the life of the depreciating structures, from a replacement method, enjoined by the state court, to a method using depreciated value as the rating base, enjoined by the Supreme Court of the United States. It is thus a case where the neglect to provide in the rates charged for the accruing depreciation cannot be said to be wholly the fault of the Spring Valley Company. In any event, under the rule of the highest court, the plaintiff has lost the unamortized depreciation in its existing structures; phrased otherwise, we must treat it as already paid, contrary to the fact. Now of the two methods of amortization where investment return is rated upon depreciated value, namely the modified sinking-fund method, and the straight-line method, the latter has been seen to involve, at any point in the plant's life, the greatest deduction for accrued depreciation of capital in structures. This is strikingly illustrated by ————'s testimony. At the master's request the witness computed accrued depreciation of the Spring Valley structures and the required annual allowance by both the modified sinking-fund and straight-line methods, reproduction cost and estimated lives being of course the same. The result was as follows (Exhibits 161, 162).

	COST NEW	ACCRUED PERCENTAGE	DEPRECIATION AMOUNT	COST DEPRECIATED	ANNUAL ALLOWANCE
Modified sinking fund method..	$25,128,930	13.9	$3,496,847	$21,632,083	$277,449
Straight line method........	$25,128,930	31.2	$7,835,847	$17,293,847	$403,891

In other words, the plaintiff's capital must on ————'s estimates, by a change from the replacement method of cost-accounting, suffer a deduction of at least three and one-half millions, which the public ought to have paid in the past but did not. Shall that loss be increased to nearly eight millions merely by a choice of theoretical mathematical methods of amortization? *As I said in the report in the Contra Costa case, if I were to decide the question of present depreciated value by reference merely to formulas of amortization, I should on grounds of obvious justice, adopt the method which involves the lesser deduction from capital made on the ground of an assumed but fictitious payment in the past. This case only strengthens the conviction I have previously arrived at, that the straight-line method is entirely unsuitable as a basis of valuation of properties of long life.*

Note also the quotation on page 372 herein, from Judge Wright's opinion.

Fourth. The opinion on this subject set forth by Halford Erickson, formerly the able chairman of the Wisconsin Railroad Commission and now in private practice, in an address on "Depreciation and Its Relation to Fair Value," delivered before the conference of City Mayors and others interested in Public Utility Control, called by the then Commissioner of Public Works of Philadelphia, Mr. Morris L. Cooke, held in Philadelphia, November 10–13, 1915, is significant in this connection.

Much has been said about the relative merits of the straight line and sinking fund methods of providing for depreciation. Without going into details in this matter it can be said that the sinking fund method implies a more efficient use of the reserves. It also means that, because of such use, the amount the customers will have to contribute to cover depreciation is less than under the straight line method. *The inference that can be drawn from these facts is that the sinking fund method is the most economical and hence would also seem to be the best of the two methods from the point of view of public interest.*

In this connection it may be in place to repeat in substance something that has already been said. All virile and live enterprises are constantly in need of readily available funds for various more or less temporary uses. The ability to quickly obtain such funds often stands for material savings in more respects than one. For these and other reasons it may not be in line with the best policy to place too many restrictions upon the balance in the depreciation reserve.

Fifth. It is further to be noted that sinking fund methods were used as a basis for forming or determining judgment in the following of the cases cited:

a. Portland, Maine, by the engineers on both sides of the case,

b. Racine, by Hazen and by the engineers of the Wisconsin R. R. Commission,

c. Denver, by the Federal Court,

d. San Francisco, by the Master of the Federal Court,

e. Indianapolis, by the engineers to the Public Service Commission of Indiana, as well as by the Company's engineer,

f. East Chicago, by the engineers on both sides of the petition,

g. In the remainder of the examples cited by the writer, for reasons heretofore stated.

Wisconsin Water-Works Depreciation Reserves. Halford Erickson's discussion upon this subject, before a convention of the Central Water Works Association, held at Detroit, Mich., September 25, 1912, is interesting by way of comparison, indicating that for the Wisconsin properties investigated, the elapsed life of which was very much shorter, for the most part, than were those of the examples here cited in table 1, the "percentage condition" of the properties indicated by the reported depreciation reserves, amounted to approximately 91 per cent, ranging from about 95 per cent to 80 per cent in the 23 examples cited by Erickson. The corresponding accrued depreciation thus varied from 5 to 20 per cent; and the annual percentage or fund for depreciation, based upon total property including land, varied from 1.12 per cent to 2.61 per cent, averaging 1.53 per cent. The elimination of the value of the land would have had very little effect upon these averages, as the amount of land involved in the Wisconsin water works cited is usually substantially less than 10 per cent of the combined value of land and structures.

TABLE 2

*Depreciation reserves—Wisconsin water utilities**

	POPULATION OF CITY (1910 CENSUS)	COST OF REPRODUCTION NEW	PER CENT CONDITION	PRESENT VALUE	COMPOSITE LIFE (STRAIGHT LINE)	COMPOSITE LIFE (4 PER CENT SINKING FUND)	ANNUAL FUND (STRAIGHT LINE)	PER CENT OF FUND TO TOTAL PROPERTY INCLUDING LAND
					years	*years*		
1	40,384	$690,001	94.6	$653,070	67.29	58.00	$8,548	1.24
2	25,531	531,020	93.4	496,346	49.86	44.34	8,212	1.55
3	11,594	401,581	94.0	377,517	63.11	56.25	5,642	1.41
4	16,773	268,687	84.6	227,445	51.96	47.68	4,458	1.66
5	14,610	318,327	91.5	291,022	61.62	56.95	4,784	1.50
6	8,893	185,148	92.3	170,824	67.60	59.60	2,464	1.33
7	8,692	127,897	88.4	113,060	48.11	55.74	2,325	1.82
8	5,629	109,432	94.7	100,502	60.55	53.30	....	....
9	3,739	101,360	93.1	94,319	44.76	44.16	1,145	1.13
10	7,196	84,276	90.2	77,201	60.03	55.57	1,076	1.28
11	5,036	73,493	90.1	66,216	56.99	50.65	1,163	1.58
12	3,830	61,139	92.0	56,285	66.33	58.38	812	1.33
13	2,675	36,947	92.2	34,072	55.51	51.07	577	1.56
14	2,907	36,899	90.1	33,225	59.31	51.75	518	1.40
15	2,582	49,855	92.9	46,315	54.66	48.69	748	1.50
16	1,808	23,138	89.9	20,804	69.77	62.04	286	1.24
17	1,833	11,784	79.6	9,937	36.49	37.00	288	2.44
18	804	8,115	90.6	7,334	46.40	45.75	162	2.00
19	15,125	242,327	92.0	224,483	62.90	58.12	2,901	1.20
20	13,027	220,382	92.9	204,716	66.19	58.51	2,472	1.12
21	13,894	217,611	93.1	202,579	63.69	56.21	2,784	1.28
22	18,797	309,449	90.2	279,312	53.49	46.93	8,088	2.61
23	6,324	120,816	91.7	110,426	55.16	49.33	1,839	1.52
Arithmetical average.....	10,076	$183,899	91.0	$169,435	57.55	52.43	$2,786	1.53

* From paper by Halford Erickson for the Convention of Central Water Works Association, Detroit, Mich., September 25, 1912.

Other data upon depreciation of water works structures. Of less significance than the data obtained from the complete life histories of water works properties are the results of thorough examination and estimate of depreciation of such properties, at any one time or period.

RECORD DATE GENERALLY DECEMBER 31	LOCATION	OWNER	AGE OF PLANT	POPULATION
			years	
	Western States			
1913	San Francisco, Cal.	Spring Valley Water Company	55	453,000
1914	California	Water Company	—	300,000
1914	Denver, Col.	Denver Union Water Company	43	242,000
	Southern States			
1912	Texas	Water Company	35	107,000
1909	Knoxville, Tenn.	Knoxville Water Company		48,140
1910	Macon, Ga.	Macon Water, Gas and Electric Company	29	39,700
1913	Columbia, Tenn.	Columbia Water Company	29	6,700
1917	Florida	Water Company	28	56,250
	Central States			
1916	Indianapolis, Ind.	Indianapolis Water Company	45	276,000
1911	Des Moines, Iowa	Des Moines Water Company	29	90,000
1916	Indiana	Water Company	22	29,600
1911	Illinois	Water Company	26	26,600
1914	Pennsylvania	Water Company	31	16,000
1913	Racine, Wis.	Racine Water Company	26	38,000
1916	Dayton, O.	City Water Department		145,000
	Eastern States			
1912	New Jersey	Water Company	63	371,000
1916	Pennsylvania	Water Company	66	340,000
1911	Pennsylvania	Water Company	57	232,000
1916	New York	Water Company	67	102,000
1916	Pennsylvania	Water Company	23	90,000
1907	Portland, Me. et als.	Portland Water District	39	78,200
1914	Rhode Island	Water Company	36	28,837
1914	New Hampshire	Water Company	60	28,000
1903	Waterville, Me. et als.	Kennebec Water District	16	17,600
1912	Massachusetts	Water Company	28	15,600
1913	Bristol, Conn.	Bristol Water Company	28	14,274
1906	Massachusetts	Water Company	24	7,240
1911	Rumford Falls, Me.	Rumford Water District	18	3,410
1907	Livermore Falls, Me.	Livermore Water District	8	3,140
1906	North Conway, N. H.	North Conway Water District	23	1,690
Totals			(954)	(3,206,981)
Averages			35.3	106,900
Maximum			67	453,000
Minimum			8	1,690
Normal conditions (approximate)				

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* Fixed by commission as equitable.

† Valuation by S. G. Pollard brought down to date.

‡ Abnormal as City does not compensate Water Department for Fire Protection Service. O

§ Average of Plaintiff and Defendant.

TABLE 3

Depreciation of water works—structural plant only

OF NT	POPULATION	GROSS REPRODUCTION COST OF EXISTING STRUCTURES ONLY INCLUDING OVERHEAD AND INTEREST ON PRE-WAR BASIS	GROSS ANNUAL REVENUE	ACCRUED DEPRECIATION			ANNUAL DEPR
				On existing plant (structures)		Abandoned structures, amount	Amount
				Amount	Per cent		
rs							
5	453,000	$21,537,000	$3,388,000	$2,800,000	13.0	$3,120,000	$218,000
—	300,000	1,650,000					150,000
3	242,000	10,411,000	1,386,000	1,321,000	12.7	1,421,000	140,000
5	107,000	2,136,000	390,000	440,000	20.6		40,000
	48,140	1,211,000	175,000	121,000	10.0		15,000
9	39,700	655,248	115,000	101,120	15.4		5,580
9	6,700	105,633	25,000	23,600	22.3		2,200
8	56,250	913,000	209,000	118,000	12.9	40,000	12,000
5	276,000	7,435,000	1,133,000*	736,000	9.9	883,000	76,000
9	90,000	2,731,000	304,000	362,000	13.2		30,428
2	29,600	609,000	108,000	64,000	10.5	94,000	7,600
6	26,600	258,000	58,900	56,700	22.0		3,300
1	16,000	410,000	53,000	81,000	19.7		5,000
6	38,000	1,219,000	140,840	70,600	5.8	19,000	26 years recor
	145,000	3,834,000†	278,000	846,000	22.1		55,000
3	371,000	8,459,000	1,095,000	1,048,000	12.4		95,754
6	340,000	10,055,000	1,114,000	1,325,000	13.2		111,000
7	232,000	7,288,000	856,000	500,000	6.9		59,000
7	102,000	4,509,000	439,000	352,000	7.8	285,000	35,000
3	90,000	3,154,000	295,000	272,000	8.6	250,000	23 years recor
9	78,200	2,594,000	295,000	498,000	19.2	137,000	39 years recor
6	28,837	1,656,000	210,000	236,000	14.2		19,000
0	28,000	917,000	101,000	151,000	16.5		11,000
.6	17,600	329,000	33,500§	47,000§	14.3		4,200
8	15,600	486,000	55,700	61,750	12.7		4,240
8	14,274	444,000	44,250	31,500	7.1		3,380
4	7,240	145,000	46,000	33,000	22.7		2,400
.8	3,410	167,000	12,750	14,800	8.9		1,805
8	3,140	85,000	7,520	2,600	3.1		538
3	1,690	35,000	4,200	5,800	16.6		400
4)	(3,206,981)	(95,437,881)	(12,372,660)	(11,719,470)	(394.3)		
3	106,900	3,181,300	426,700	404,000	**13.6**		
7	453,000	21,537,000	3,388,000	2,800,000	22.7		
8	1,690	35,000	4,200	2,600	3.1		
					8-13%		

ection Service. Omitted from total and average.

ied es, t	ANNUAL DEPRECIATION ALLOWANCE, EQUITABLE AMOUNT					COMMENTS
	Amount	Per cent of gross reproduction cost	Per cent of depreciated reproduction cost	Per cent of gross annual revenue	Cents per capita	
000	$218,000	1.01	1.16	6.4	48	By Federal Court Master
	150,000				50	Allen Hazen
000	140,000	1.34	1.54	10.1	58	By Federal Court
	40,000	1.87	2.36	10.2	37	Metcalf
	15,000	1.24	1.38	8.6	31	Court
	5,580	0.85	1.01	6.1	18	Board of Arbitration
	2,200	2.08	2.68	8.8	33	Board of Arbitration
000	12,000	1.31	1.51	5.8	21	Metcalf (12,550 additional population supplied wholesale omitted.)
000	76,000	1.02	1.13	6.7	28	Indiana Public Service Commission
	30,428	1.11	1.29	10.0	34	Metcalf
000	7,600	1.25	1.40	7.0	26	Metcalf
	3,300	1.28	1.64	5.6	12	Metcalf
	5,000	1.22	1.52	9.4	31	Metcalf
00	26 years record	0.45	0.47	6.7	15	Allen Hazen. Life History
	55,000	1.43	1.84	(19.8)‡	38	
	95,754	1.13	1.29	8.7	26	Metcalf
	111,000	1.11	1.50	10.0	33	Metcalf
	59,000	0.81	0.87	6.9	25	Metcalf
000	35,000	0.73	0.78	8.0	34	Metcalf
000	23 years record	1.29	1.39	8.0	48	Life History. Metcalf.
000	39 years record	1.29	1.46	9.6	45	Life History. Average invest. 18 years
	19,000	1.15	1.34	9.1	66	Metcalf
	11,000	1.20	1.44	10.9	39	Metcalf
	4,200	1.28	1.49	12.5	24	
	4,240	0.87	1.00	7.6	27	Metcalf
	3,380	0.71	0.76	7.1	22	Metcalf
	2,400	1.65	2.14	5.2	33	Metcalf
	1,805	0.89	0.97	11.6	43	Metcalf
	538	0.63	0.65	7.2	17	Metcalf
	400	1.14	1.37	9.5	24	Metcalf
		(33.34)	(39.38)	(242.4)	986	
		1.15	**1.36**	**8.4**	**33**	
		2.08	2.68	19.8‡	66	
		0.45	0.47	5.2	12	
		0.9–1.3	**1.0–1.4**	**8–12**	**35–45**	

There is shown in table 3 on "Depreciation of Water Works Structural Plant Only," the results of such examination of 28 different water works properties made by the author, and of two made by others of which he has had some knowledge. For convenience they have been assembled in four groups, covering three water works properties in the western states, five in the southern states, seven in the central states and fifteen in the eastern states.

Comments upon table 3. These records are perhaps of some confirmatory significance, having been based upon detailed examination, analysis and judgment of the author, by whom also were made a majority of the records covered by table 1.

They indicate that the accrued depreciation upon the existing structures is likely to lie within the previously stated range (8 to 13 per cent) varying in the thirty examples cited, from 3 to 23 per cent, averaging 13.6 per cent.

The range of average or fair annual depreciation allowances for normal water works structures indicated in the thirty examples cited, varies from

	Average of all records
0.9 to 1.3 per cent of gross-reproduction-cost-new	1.15 per cent
1.0 to 1.4 per cent of depreciated-reproduction-cost	1.36 per cent
8.0 to 12.0 per cent of gross-annual-revenue	8.40 per cent
35 to 50 cents per capita	33 cents

The extremely high and low values found for accrued depreciation in the examples cited, are readily accounted for by the abnormal conditions or structural problems involved.

The accrued depreciation found in the analyses summarized in table 3 have also been grouped as between pumping plants and gravity plants, with results shown in table 4.

These results indicate that within the limits of the examples cited —which cover 7 gravity plants and 21 pumping plants, the Livermore Falls record being omitted as involving too young a plant to be of significance in such a study—there appears to be no substantial difference, within the limits of the accuracy of such work, in the average percentage of accrued depreciation upon gravity and pumping plants, that for the gravity plants averaging 13.9 per cent, and for the pumping plants 14.0 per cent.

TABLE 4

Age and depreciation of pumping and gravity water works

PUMPING PLANTS

Location	Age	Depreciation
	years	*per cent*
Texas	35	20.6
Knoxville, Tenn.		10.0
Macon, Ga.	29	15.4
Columbia, Tenn.	29	22.3
Indianapolis, Ind.	45	9.9
Des Moines, Ia.	29	13.2
Indiana	22	10.5
Illinois	26	22.0
Racine, Wis.	26	5.8
Dayton, O.		22.1
New Jersey	63	12.4
Pennsylvania	66	13.2
Pennsylvania	57	6.9
Pennsylvania	23	8.6
New York	67	7.8
Waterville, Me.	16	14.3
Massachusetts	28	12.7
Rhode Island	36	14.2
New Hampshire	60	16.5
Massachusetts	24	22.7
Florida	28	12.9
Totals	709	294.0
Average	37	14.0

GRAVITY PLANTS

Location	Age	Depreciation
	years	*per cent*
San Francisco, Cal.	55	13.0
Denver, Colo.	43	12.7
Portland, Me.	39	19.2
North Conway, N. H.	23	16.6
Bristol, Conn.	28	7.1
Rumford Falls	18	8.9
Pennsylvania	31	19.7
Totals	237	97.2
Average	34	13.9

SUMMARY

Number of plants	Type of plants	Average age	Average accrued depreciation on existing plant
		years	*per cent*
21	Pumping	37	14.0
7	Gravity	34	13.9
28	Combined record	36	14.0

Livermore Falls record omitted as too young (8 years) to be significant.

CONCLUSIONS SUGGESTED BY THE ANALYSIS OF THE LIFE HISTORIES OF ELEVEN WATER WORKS PLANTS AND OTHER CONFIRMATORY DATA SUBMITTED HEREIN

1. *In reviewing records of depreciation care must be taken to determine their completeness.* Many so-called depreciation records, purporting to give normal life records or expectancies for structures, are really records of plant failures based upon the experience had with the structures which failed and had to be replaced, without consideration of the life history of the remaining structures which did not fail and were still rendering good service—thus overestimating the fair or normal depreciation allowance.

On the other hand, in determining the amount of abandoned property, recollections of old employees are not alone always a safe substitute for specific records, and prudence dictates the necessity for making reasonable allowance for omissions in such cases,—lest depreciation be underestimated. Also for overhead costs frequently not charged to construction in the past.

2, *The accrued depreciation upon existing structures* involved in *old* operating water works properties, is likely under normal conditions to amount to from 8 to 13 per cent of their cost,—varying in the eleven plants cited, from about 6 to 19 per cent, and averaging 11.6 per cent—the depreciation upon the more substantially built properties having structures of more enduring character corresponding to the lower limits, and upon the plants having structures more perishable or less well maintainted, approaching the higher limits. In young properties, built a decade more or less ago the accrued depreciation upon existing structures is likely to be within two-thirds of the above stated amounts. These allowances appear reasonable in the light of the record of abandoned property found below under No. 4.

3. Vice-versa, the *operating condition of old, well-established and operating water works properties*, is likely to lie between 87 and 92 per cent of the cost new of existing structures; and between 92 and 97 per cent of *young properties* ten years, more or less, old.

4. The *abandoned structures* in the examples cited, ranged from 2 to 13 per cent, averaging 8.4 per cent, of the combined cost of the existing and abandoned structures,—indicating the fairness of the allowances cited in No. 2 above, for normal accrued depreciation upon existing structures.

5. The *total depreciation upon existing plus abandoned structures* ranged in the examples cited, from about 7 to 26 per cent, averaging 19 per cent, of their cost new; and as based *upon the net or depreciated cost of the existing structures only*, from about 8 to 30 per cent and averaging 21 per cent, depending upon the character of the plants.

6. The fair average annual depreciation, expressed in different terms, is perhaps the most significant and helpful measure, and should normally lie within the following limits:

a. The average annual depreciation upon the gross reproduction cost of the existing structures of normal water works properties, is likely tc lie between 0.9 and 1.3 per cent of their cost new, the average of the eleven examples cited being 1.17 per cent, the smaller percentage corresponding to the properties having structures of enduring character, such as large storage reservoirs, built of earth, masonry conduits, supply conduits and cast iron distribution systems of pipe of ample dimensions; the larger amount corresponding to plants having structures relatively more perishable, such as reinforced masonry dams, wooden supply pipes, pumping stations, filter plants and supply mains of less generous proportions.

b. The average annual depreciation upon the depreciated cost of the existing structures of normal water works properties, is likely to lie between 1.0 and 1.4 per cent of their cost new, the average of the cases cited being 1.3 per cent, the variation being due to the factors cited above.

c. The average annual depreciation in percentage of gross annual revenue of normal water works plants, is likely to lie between 8 and 12 per cent, being dependent upon the character of the structures, the range in the eleven examples cited being from 7 to 20 per cent, averaging 10.5 per cent. While this basis of determining depreciation is not an absolute one, within the range of normal earnings, it is an exceedingly useful check upon other methods of computation, and it is an easy and advantageous method of accounting depreciation when controlled by periodic detailed analysis of structural depreciation. It is likely that this method of allowing for depreciation will come into more general use with a lapse of time and accumulation of reliable data.

d. The average annual depreciation per capita in normal water works properties is likely to be between 40 and 50 cents, ranging from 15 to 89 cents, and averaging 45 cents in the eleven cases cited. The extremely low and high values are abnormal ones, as appears from the detailed discussion upon them. In theory the per capita unit is based upon the existence of a more or less normal type of water works, the gravity plants generally involving greater cost of structures but lower rate of depreciation than the pumping plants.

This basis of comparison (d) is to be used as a means of checking other methods of computation, rather than as a direct means of determining fair annual depreciation allowance.

7. *The range from normal results* may be considerable in special cases, as appears from some of the examples cited in table 1, but full knowledge of the relative local situation and character of plant, and careful investigation of its actual structural condition, will mate-

rially reduce the difficulty of using normal-type results as a basis for determining reasonable allowances for accrued and annual depreciation for more or less abnormal cases.

8. *Experience in determining the accrued depreciation upon old water works properties has shown that the application of the straight line formula gives excessive results, clearly at variance with the observed condition of the structures.* The results obtained from the sinking-fund, compound-interest, or equal-annual-payment methods, are much more normal.

In short lived property, or comparatively new structures, the results differ less markedly. In any event, the condition of the structures should be carefully observed, and the results obtained by application of any formula or method for determining depreciation, should be checked by and made to accord with the observed condition of the structures and weight should be given to such carefully observed precedent as may be available with respect to accrued depreciation upon and life histories of old water works, such as those reported herein.

By degrees experience will crystallize in more direct allowance and limitations under observed conditions, independent of formulas.

9. *The unfairness of arbitrary application of accounting methods for determining accrued depreciation,* has been clearly set forth herein in the discussion upon Reasons for Use of Sinking Fund Methods for Determining Accrued Depreciation (p. 383) and in the quotations from the opinion of Judge H. M. Wright, Standing Master in Chancery of the Federal Court of the District of Northern California, in Spring Valley Water Company v. City and County of San Francisco, Cal. (1916), pages 372 and 384.